ENHANCING THE WATER POVERTY INDEX: TOWARDS A MEANINGFUL INDICATOR

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1. Abstract

Several issues impact the ability of people to access safe water and improved sanitation. Among them are the social, economic, and environmental issues. However, they are often treated separately, and not as an integrated, dynamic process.

This paper is concerned with the development and underlying methodology of an aggregated index which combines biophysical, social, economic and environmental data in one single and comparable number to produce a holistic tool for policy making. It will be first tested at basin level in Peru (International Catamayo – Chira Basin), and main results will be presented and discussed. Furthermore, and in the light of its implementation, the need to promote additional research will be evaluated, so as to apply same index at different scales (at least regional and community scale).

2. Introduction

Inadequate water management undermine both human capital (through morbidity) and natural capital (through pollution), providing a major shortcoming to welfare growth. As a result, to suitably manage water resources has an important role to play in poverty alleviation in developing countries. Moreover, water is increasingly seen as one of the most critically stressed resources, and demands the attention of policy makers, resource managers, and governments. Accordingly, appropriate policy frameworks are required as essential tools to support behavioural change and to foster sustainability. An essential prerequisite to effective policy making is to access consistent information through accurate monitoring backed up by rigorous interdisciplinary science, which is mainly dependent on a set of reliable and objective indicators. Similarly, with limited resources (in low-income countries), targeting their allocation requires transparency of decisions to be made and of priorities to be assessed, so that water can be delivered to where it is most needed, enabling a more equitable distribution of this resource. Once more, a comprehensive compilation of non specific indicators is needed.

Against this background much effort has gone into the development of indicators of water problems in recent years (Falkenmark, 1986; Joint Monitoring Programme, 2000; Ohlsson, 2000; Feitelson and Chenoweth, 2002; Sullivan, 2002; Chaves and Alipaz, 2007), since the international commitment to the Millennium Development Goals has increased the necessity to come up with feasible indicators. There is a strong need to develop integrated tools for (i) assessing the development process, (ii) informing and orienting policy-making, (iii) comparing situations, and (iv) measuring performance. In brief, effective water indicators should need to focus on the structural impediments to the sustainable supply of water, so as to facilitate policy responses.

Based on these four goals and aimed at assessing the water scarcity and accessibility to water of poor populations, the water-poverty interface has been advanced as an indicator through the Water Poverty Index (Sullivan, 2002). It (WPI) is an integrated assessment of water stress and scarcity, linking physical estimates of water availability and the socio-economic factors which impact on access and use of this resource. The purpose of a water poverty index should thus be to identify the ability of countries or regions to address their water supply needs. In other words, it is hoped that the development of such an index will enable decision makers to target (at various levels) crosscutting issues in an integrated way, by identifying and tracking the physical, economic and social drivers which link water and poverty. The core theoretical framework of the index encompasses water **resources**, **access** to water, **capacity** for sustaining access, the **use** of water and the **environmental factors** which impact on the ecology which water sustains.

There is consensus on stating that this multidimensional approach to water poverty assessments appears attractive, and its accuracy has already proved to be meaningful at all different levels: national (Lawrence et al., 2002; Komnenic, 2007), regional (Heidecke, 2006), and local scale (Sullivan et al., 2003; Cullis and O'Regan, 2004).

Nevertheless, criticism has also been made of WPI on several grounds (Feitelson and Chenoweth, 2002; Molle and Mollinga, 2003; Shah and van Koppen, 2006; Jiménez et al., 2007; Komnenic, 2007). In short, it is the weights assigned to the components of the WPI (which are undefined) one major shortcoming; since when contextually defined weights are used, the index loses its universality and cannot be employed for comparison. Similarly, Molle and Mollinga (2003) criticize the WPI for conflating disparate (and often correlated) pieces of information with arbitrary weights resulting in questionable results. At the same time, the WPI has also proved to be inadequate for assessing the complexity of the water issues (Komnenic, 2007), and this is acknowledged by the authors (Lawrence et al., 2002; Sullivan, 2002) who note that 'the information is in the components rather than in the final single number'.

Finally, water indicators could focus either upon the current situation (such as the WPI), in terms of the water supply and sanitation conditions present in each country or region, or it could emphasize the importance of causality and thus incorporate cause-effect relationships, in particular considering that water resources management is a dynamic and holistic process. The second approach provides stakeholders and decision-makers with a valuable tool to see the interconnections between the parameters. Likewise, there is evidence that central aspects in water supply, such as the functionality of the facility, the principle of cost-recovery or Operation and Maintenance issues, have often been side-lined in the development of an appropriate aggregate index. In this respect, there is a need to develop indicators to assess the degree to which water supply and sanitation services are likely to be sustained. They should thus focus more on structural issues, in particular the ability to provide water in a sustainable manner, where sustainability is broadly defined to include among others equity issues, sustainable financing, and water resources management.

On the basis of these premises and taking WPI as a starting point, we propose a definition of an enhanced Water Poverty Index and its respective conceptual framework, by integrating the concept of causality and by including sustainability issues. It is believed that both improvements make the index more transparent and acceptable to different stakeholders.

3. Objectives and Method

The objective of this paper is to develop a meaningful integrated index to assess water and poverty linkages. Based on the Water Poverty Index, it proposes an appropriate holistic tool to both monitor sector progress and to prioritize resources allocation. In particular, the specific purposes of this research can be described as follows:

How should water poverty be accurately assessed? Are there benefits to be derived from developing one inter-disciplinary tool, which combines physical, social, economic and environmental aspects? Which indicators do we have that are at once pertinent, reliable and available? Do causal chains add relevant information to previous WPI? How should sustainability issues be included into an aggregated index?

This study is aimed at being applied research, and to fit academic debate to the reality on the ground is essential. Therefore, the index has been applied to an international basin in Peru - Ecuador to demonstrate its applicability. The theoretical framework of the index is provided in Section 4. Its development to be tested at basin scale in Peru is briefly described in Section 5. Section 6 presents major findings of this case study, which was performed in the beginning 2008. Future research and further improvements of the index are outlined in Section 6 to conclude the study.

4. Integrating causal chains and sustainability issues in the Water Poverty Index

The conceptual framework adopted comprises two dimensions, combining a classification in terms of subject/issue with a classification in terms of the position along the causal chain.

Figure 1. The causal chain - water poverty issues matrix

First, it uses the Pressure - State - Response model introduced in 1993 by the OECD (OECD, 1993), which provides a means of selecting and organising indicators in the context of a causal chain that links indicators of pressures, to state indicators, and to indicators of societal response. The idea seems to be that by placing indicators within a causality-issue matrix, the cause - effect relationships, interconnections between the parameters, and feedbacks will become obvious.

- **Pressure** indicators include pressures from human activities exerted on the environment, particularly on water resources. “Pressures” here cover indirect pressures (i.e. human activities themselves and development trends and patterns of significance) as well as direct pressures (e.g. the discharge of pollutants). Indicators of pressures are thus closely related to water consumption patterns and reflect resource use intensities.
- **State** indicators relate to the quality and quantity of water resources, as well as to existing capacities to appropriately manage them. They depict the current situation (the state) concerning major issues affecting water poverty, and as such they reflect the ultimate objective of sector-related policies.
- **Societal responses** show the extent to which society responds to water sector-related concerns. They refer to individual and collective actions and reactions, intended to (i) mitigate, adapt to or prevent human-induced negative effects on water resources; (ii) reverse environmental damage already inflicted; and (iii) preserve and conserve water resources.

Second, and equal to WPI, it distinguishes a number of aspects which reflect major preoccupations and challenges in low-income countries related to provision of water, and includes specific indicators to somehow assess the degree to which water supply and sanitation infrastructure is likely to be sustained. Thus, for each issue, indicators of pressure, state and societal responses are defined. A brief description of each sub-index and respective variables follows (Table 1).

- **Resources**: This index combines surface and groundwater availability, taking account of seasonal and inter-annual variability.
- **Access**: There are two components to this index: (i) percentage of the population with access to improved water sources; and (ii) percentage of the population with access to sanitation. In addition, equity in access should be assessed as a key sustainability criterion.

- **Capacity**: This index tries to capture those socio-economic variables which can impact on abilities that communities should have to properly manage water resources. It should assess adequacy of sector-related institutional framework.
- **Use**: This index captures the use we make of the water, and tries to take into account that water availability for growing food (agriculture) should be as important as for domestic and human consumption. On a sustained basis, the efficiency of how water resources are used is also assessed.
- **Environment**: This index tries to capture a number of environmental indicators to evaluate the degree to which water and the environment are given importance in a country's strategic and regulatory framework.

Table 1

Structure of Index and variables used

5. Developing the enhanced WPI concept at basin scale

The concept of water poverty is thus assumed to be a function of physical availability of water resources (R), extent of access to water (A), effectiveness of people's ability to manage water (C), ways in which water is used for different purposes (U), and the need to allocate water for ecological services (E). Considering that it is a dynamic and holistic concept, a pressure-state-response model has been applied to those five components in a matrix scheme. Numerically, the enhanced WPI is given by:

$$WPI = (R + A + C + U + E) / 5 \quad (1)$$

As seen from previous equation, equal weights are used for all indicators, since there is no evidence that it be otherwise. To each parameter or combination of indicators, a score between 0 and 1 is assigned. Therefore, both the quantitative and qualitative parameters are divided in four scale scores (0.25, 0.50, 0.75, and 1.0), where a value of 0 is assigned to the poorest level, and 1 to optimum conditions. This allows for the use of spreadsheets instead of equations or other complex functions. The full description of levels and scores of all parameters is briefly discussed below and presented in Tables 2, 3, and 4, respectively.

Table 2

Description of WPI – Pressure parameters, levels and scores

Table 3

Description of WPI – State parameters, levels and scores

Table 4

Description of WPI – Response parameters, levels and scores

The 'Resource' component measures availability of water resources. The increase in population puts greater pressure on water resources, and it has been taken as the Pressure parameter. The state parameter is a balance between total exploitable water available and use of this resource for both domestic and economic purposes. Likewise, water quality is also an important factor influencing the accessibility of the resource, and this aspect has also been considered. The Response parameter is assumed to be the basin Human Development Index's education sub-indicator. Since this indicator measures the population educational level, high values of HDI-Education would correlate with the ability and willingness of the population to participate in and improve the watershed management. This correlation was observed in several basins in Brazil, where higher societal involvements in water resources management occurred in basins with higher educational levels (Chaves and Alipaz, 2007). Furthermore, it is a simple and available parameter, facilitating its use.

In the 'Access' indicator there are two sets of parameters: one relative to access to safe water and the other to improved sanitation. In this respect, though National Population Census carried out in 2005 and 2007 has provided relevant data to assess percentage of population which access basic services; a more accurate analysis to tackle gender and poverty issues in service provision should be required in terms of sustainability. The Response parameter is based on analyzing suitability of infrastructure to treat water for domestic purposes and sewage before its discharge to environment. It takes into consideration current capacity of treatment plants as well as the ability to properly operate and maintain them.

'Capacity' comprises a set of indicators focusing on the human development of the basin, though where possible it should capture water sector institutional capacity. It is generally believed that services are better sustained when all potential users (both women and men, poor and better off) influence the process of service establishment (Gross et al., 2000). Therefore, the Pressure parameter is related to gender issues and measured through the percent variation in the women basin HDI – Education in the last 2 years, which gives an indication of how women are being empowered within the community. The parameter selected for Capacity State is the basin Human Development Index – HDI. The Response parameter is taken as the HDI Income, a HDI sub-indicator which accounts for the basin population income. The advantage of using the HDI and its sub-indicators is that they are often available on a district basis. They can be, in turn, easily averaged for the basin, using the population as the weighing factor. Nevertheless, and as previously outlined, more accurate data related to sector institutional framework and its capacity to support water and sanitation service provision is needed to properly assess this component.

The 'Use' component focuses on the consumption of water in households as well as in different productive sectors, such as industry and agriculture. The Pressure parameter is based on prevalence of water-related diseases, as a measure of inadequate water use and poor hygienic practices (Cairncross and Feachem, 1993). Since main demand of water is for agricultural use, the State parameter is estimated by the proportion of irrigated land to total cultivated land. On a sustained basis, water-use efficiency has been evaluated as a Response parameter.

Finally, the 'environment' component combines variables which are likely to impact on ecological integrity (such as biodiversity, environmental degradation, soil erosion...). The pressure parameter for the Environment Indicator assesses the impact on environment of all different pollutant sources located in the basin. To measure the environmental impact, it takes into consideration different aspects: (i) adequacy of treatment before pollutant discharge; (ii) number of different environmental factors affected (water, soil, atmosphere, biodiversity…); (iii) type of source (local or regional); and its continuity (permanent, occasional or potential). The total impact is then a function of number of pollutant sources and their individual impact. This State parameter is correlated to percentage of total area under natural vegetation in the basin. In the case of the Response indicator, it is estimated by analyzing implementation of sector-related policies to protect the environment as well as the envisaged basin sector expenditures. It should reflect the response by stakeholders and decision-makers in tackling environmental problems.

6. Applying the enhanced WPI to the Catamayo – Chira Basin (Perú)

To exemplify the utilisation of enhanced WPI, it has been applied to the Catamayo - Chira River basin, an international 17,200 km^2 watershed shared between Peru and Ecuador. It is made up of six different sub-basins, and their major features are shown in Table 5.

Figure 2. The Catamayo – Chira River Basin and its subbasins

Table 5

Main features of Catamayo – Chira River Basin

In this study nonetheless WPI has only been tested in the three basins located in Peru, where better environmental and social data were available. It should be noted that aimed at setting a methodology replicable within different contexts, the selection of indicators has been not only based on what is desirable to measure but on the need to use existing and consistent data, avoiding further data collection.

After data compilation, information has been classified following the WPI-PSR framework. Once the parameters of all five components are obtained, the WPI is calculated according to Eq. 1. The results are presented in Table 6.

Table 6

Final values for all e-WPI parameters

At the same time, to illustrate the complexity of water issues, a pentagram has been developed (Figure 3). By showing the values of all five components in a visually clear way, it directs attention to those water sector needs that require urgent policy attention. Likewise, different pentagrams for the Pressure – State – Response components help cause-effect relationships not to be lost (Figure 4; Figure 5; and Figure 6).

In brief, although final WPI results in three basins are similar, different conclusions can be achieved if a thorough analysis is done focussing either on the five components of the index or on a specific position within the causal chain. It highlights the fact that "when observed separately the indicators offer a good view of the situation in that field; and when merged into one component, more information may be lost than gained" (Komnenic, 2007).

In this respect, aspects needing attention by stakeholders and decision-makers in these basins are those related to Resources State (Chira Basin), Access State and Response (Quiroz and Chipillico Basins), Use State (Chira Basin), and Environment Pressure (Chira Basin), namely improving water quality, increasing water and sanitation coverage through building and sustaining new infrastructure, reducing agricultural water demand and improving respective water-use efficiency, and minimizing the impact produced by existing pollution sources, respectively.

6. Future research and further improvements on WPI

The results discussed in this paper originated from a pilot exercise, carried out specifically to develop and test the methodology proposed. Main goal was not to discuss reliability of obtained results. It was to test the index through its application in a given context, aimed at detecting major shortcomings and pointing out future improvements.

It has been demonstrated that the index can be a powerful tool with potential for wider implementation. Because of its simplicity, the WPI appeals to policy-makers, since complexities of water situation at a particular location result to be straightforward if represented either as a single number or through a pentagram. However, the index needs to be advanced from its preliminary application and tested at other scales. In this respect, different aspects need to be answered and improved.

Data collection procedure and appropriate indicators

Composite indices are only as strong as the underlying variables. These variables should be selected, ideally, on the basis of their relevance, analytical soundness, timeliness, accessibility and other related factors. In data-scarce contexts nonetheless, information for the WPI components should come from existing sources. It is important to realize that though much data exists (often in diverse institutions), it may be inconsistent, unreliable or even invalid for what it claims to represent, so results from any assessment process should be treated with caution.

At the same time, it has been suggested that aspects related to sustainability of water schemes should be included in all five components of the index. At least, sustainable financing mechanisms at community level, gender and poverty issues in service provision, and adequacy of water sector institutional framework need to be properly assessed.

The issue of scale

Natural water resources planning unit (watersheds) generally do not align themselves with jurisdictional boundaries and political governance. Moreover, and despite the incongruence between water systems and national boundaries, the state is the basic unit for which most socio-economic data is collected, and it should be taken into account when defining suitable scales to apply indices and indicators.

There is a need to develop an index which is non scale-dependence, and geo-referenced datasets should provide the appropriate framework to assess WPI at any point on the map regardless of the scale. Within such a framework, for any specific point on the map (identified by its grid reference) detailed and accurate data from both the social and physical sciences could be linked in an integrated way.

Analysis of the components

Individual indicators are sometimes selected in an arbitrary manner with little attention paid to the interrelationships between them. It is clear that components should not be highly correlated with each other, and the index should not be highly correlated with any single component. In other words, little correlation between the different sub-indices should mean that there is no overlap between them. Thus each component does add to the information available in assessing progress towards sustainable water provision.

Different analytical approaches can be used to explore whether the variables and indicators are statistically well-balanced in the aggregated index and is thus meaningful to include them. If they are not, a revision of the sub-indicators might be needed.

Weighting and aggregation of the components.

Ideally, weights should reflect the contribution of each indicator and variable to the overall index. Since a composite index does allow for different weights, statistical models could be used to help the assignment process. Alternatively, participatory methods that incorporate various stakeholders - experts, citizens and politicians – could be also promoted. Regardless of the final weights, it should be noted that the information is in the components rather than the final single number, and it is possible that a straight average is as useful as a weighted one. Clearly, the issue of weights is something that will be further addressed in future research.

Aggregation methods also vary. In a linear or geometric aggregation, weights express trade-offs between indicators. A shortcoming in one dimension thus can be offset (compensated) by a surplus in another. This implies an inconsistency between how weights are conceived, since they should measure the importance of the associated variable. Thus, if one needs to assure that weights remain a measure of importance, other aggregation methods should be used, in particular methods that do not allow compensability. Moreover if different goals are equally legitimate and important, a non-compensatory logic might be necessary. This is the case of e-WPI, where highly different dimensions are aggregated, including the physical, social and economic data. If it is decided that an increase in economic performance cannot compensate a loss in social cohesion, or a worsening in environmental sustainability, then neither the linear nor the geometric aggregation is suitable. A non-compensatory multi-criteria approach could assure non-compensability by finding a compromise between two or more legitimate goals.

7. Discussion

In this paper we have demonstrated the interest in, and relevance of, the use of an integrated indicator as an effective water management tool in decision making processes. The great advantage of the index is that it provides a reasonably simple process to combine knowledge from both the biophysical and social sciences to produce one single and comparable value, with its associated pentagram, enabling more comprehensive understanding of the meaning of the results.

In order to allow for higher simplicity and wider applicability, the index tested here uses a relative small number of indicators and parameters. Though its five components and 19 parameters may not span the whole sustainability spectrum, the use of more indicators and variables would hinder its applicability, particularly in data-scarce contexts. Also, an additive structure with equal indicator weights is preferred, since it appears to make the index more transparent and acceptable to different stakeholders and decision-makers. Another advantage is that all parameters have been assessed with readily available data, and no further data collection has been undertaken.

This paper also provides some discussion on the challenges associated with the integration of data from different disciplines, and the application of that data at different scales. Recognizing the limitations of this first attempt to test an enhanced WPI, there is no doubt that there is much room for improvement and refinement of the index structure. More research is needed and through an iterative process, a more holistic tool for policy making can be developed and adapted for use at a variety of scales.

7. References

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causal chain

WPI Components	**pressure**	**state**	**response**
resources	Indicator 1	Indicator 2	Indicator 2
access	Indicator 4	Indicator 5	Indicator 6
capacity	...		
use			
environment			

Figure 1. The causal chain - water poverty issues matrix

Figure 2. The Catamayo – Chira River Basin and its subbasins

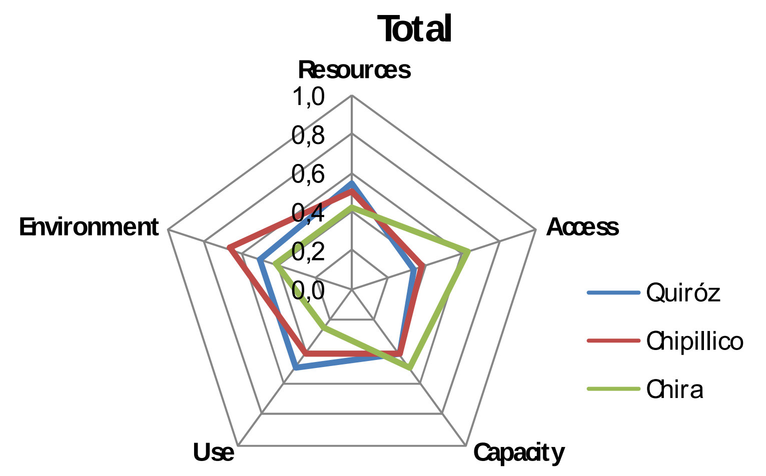

Figure 3. Pentagram presentation of the averaged P-S-R components of the WPI

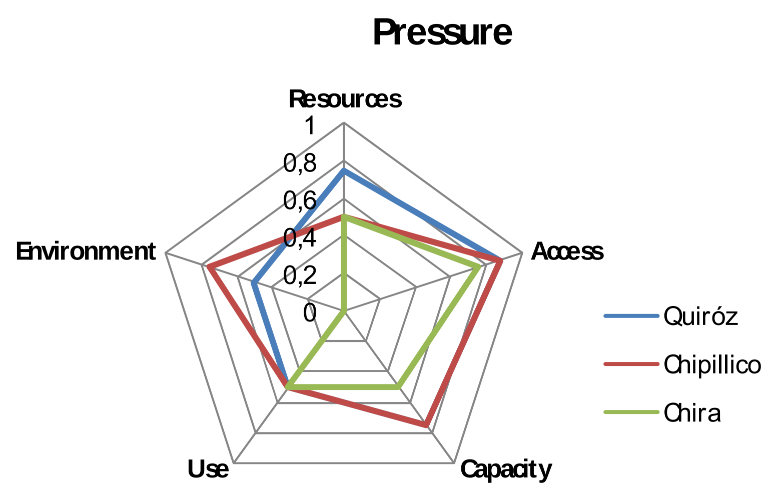

Figure 4. Pentagram presentation of the Pressure components of the WPI

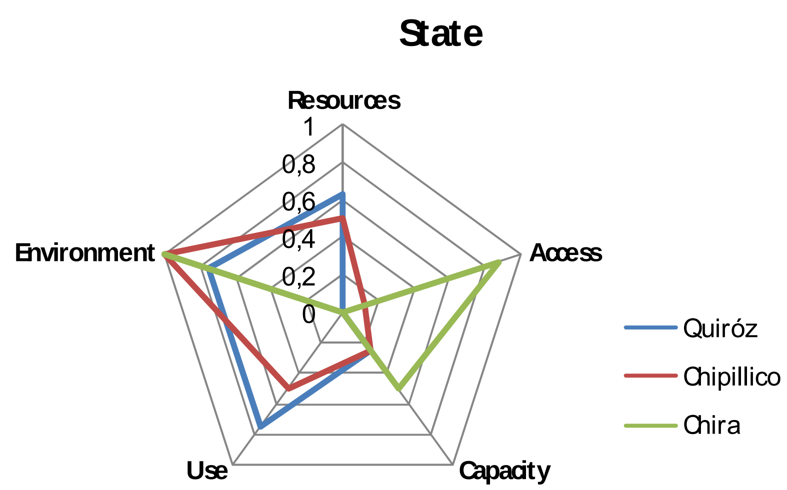

Figure 5. Pentagram presentation of the State components of the WPI

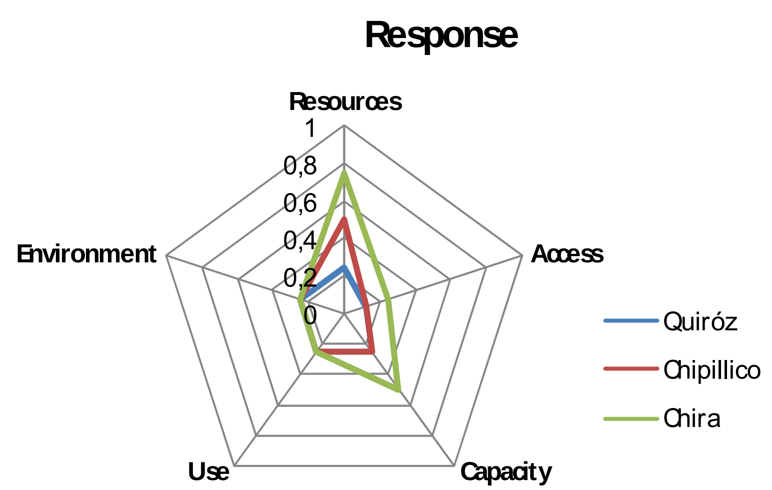

Figure 6. Pentagram presentation of the Response components of the WPI

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Table 1

Structure of Index and variables used

e-WPI Component	Variables
Resources (R)	▪ Water resources availability (Variability or reliability of water resources) ▪ Water quality ▪ Integrated Water Resources Management (*sustainability criterion*)
Access (A)	▪ Access to safe water as a percentage of population ▪ Access to sanitation as a percentage of population ▪ Equity in access (*sustainability criterion*)
Capacity (C)	▪ Water sector institutional framework ▪ Financing strategies and cost-recovery (*sustainability criterion*) ▪ Gender issues and the role of women (*sustainability criterion*)
Use (U)	▪ Domestic water consumption rate ▪ Prevalence of water-related diseases ▪ Agricultural water use ▪ Water use efficiency (*sustainability criterion*)
Environment (E)	▪ Environmental regulation and management ▪ Water stress – pollution (*sustainability criterion*)

Table 2

Description of WPI – Pressure parameters, levels and scores

Indicator	Pressure Parameters	Level	Value
Resources	Annual Population Growth Rate in the last 2 years, (PG) in % and weighted by population	PG > 4%	0
		4% > PG > 2%	0.25
		2% > PG > 0%	0.50
		0% > PG > -2%	0.75
		-2% > PG	1.00
Access (safe water)	Variation in safe water accessibility in the last 2 years, weighted by population	I· < -10%	0
		-10% < I· < 0%	0.25
		0% < I· < 10%	0.50
		10% < I· < 20%	0.75
		I· > 20%	1.00
Access (improved sanitation)	Variation in improved sanitation accessibility in the last 2 years, weighted by population	I· < -10%	0
		-10% < I· < 0%	0.25
		0% < I· < 10%	0.50
		10% < I· < 20%	0.75
		I· > 20%	1.00
Capacity	Variation in the women basin HDI – Education in the last 2 years, weighted by population	I· < -10%	0
		-10% < I· < 0%	0.25
		0% < I· < 10%	0.50
		10% < I· < 20%	0.75
		I· > 20%	1.00
Use	Water-related diseases in the basin (Wrd) weighted by population	Wrd > 20%	0
		20% > Wrd > 10%	0.25
		10% > Wrd > 0	0.50
		0 > Wrd > -10%	0.75
		-10% > Wrd	1.00
Environment	Impact of Pollutant Sources (Number of Sources * Individual Impact)	IPS > 100	0
		100 > IPS > 75	0.25
		75 > IPS > 50	0.50
		50 > IPS > 25	0.75
		25 > IPS	1.00

Table 3

Description of WPI – State parameters, levels and scores

Indicator	State Parameters	Level	Value
Resources	Basin Water Availability (Balancing use and demand)	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00
	Basin Water Quality, for domestic use	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00
Access (safe water)	% Population with access to safe water (P_{WA}), weighted by population	$P_{WA} < 35\%$	0
		$35\% < P_{WA} < 50\%$	0.25
		$50\% < P_{WA} < 65\%$	0.50
		$65\% < P_{WA} < 80\%$	0.75
		$P_{WA} > 80\%$	1.00
Access (improved sanitation)	% Population with access to improved sanitation (P_{SA}), weighted by population	$P_{SA} < 35\%$	0
		$35\% < P_{SA} < 50\%$	0.25
		$50\% < P_{SA} < 65\%$	0.50
		$65\% < P_{SA} < 80\%$	0.75
		$P_{SA} > 80\%$	1.00
Capacity	Basin HDI, weighted by population	HDI < 0,4	0
		0,40 < HDI < 0,55	0.25
		0,55 < HDI < 0,70	0.50
		0,70 < HDI < 0,85	0.75
		HDI > 0,85	1.00
Use	Agricultural water use (W_U), expressed as the proportion of irrigated land to total cultivated land	$W_U > 85\%$	0
		$85\% > W_U > 70\%$	0.25
		$70\% > W_U > 55\%$	0.50
		$55\% > W_U > 40\%$	0.75
		$40\% > W_U$	1.00
Environment	% of basin area under natural vegetation (Av)	Av < 15%	0
		15% < Av < 30%	0.25
		30% < Av < 45%	0.50
		45% < Av < 60%	0.75
		Av > 60%	1.00

Table 4

Description of WPI – Response parameters, levels and scores

Indicator	State Parameters	Level	Value
Resources	Basin HDI – Education, weighted by population	HDI < 0,45	0
		0,45 < HDI < 0,60	0.25
		0,60 < HDI < 0,75	0.50
		0,75 < HDI < 0,90	0.75
		HDI > 0,85	1.00
Access (safe water)	Improvement in adequate water infrastructure in the basin	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00
Access (improved sanitation)	Improvement in adequate sewage treatment in the basin	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00
Capacity	Basin daily per capita income, in US $ (In)	In < 1	0
		1 < In < 2,5	0.25
		2,5 < In < 5	0.50
		5 < In < 10	0.75
		In > 10	1.00
Use	Water-use efficiency	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00
Environment	Adequacy of the basins' environment sector-related institutional framework	Very Poor	0
		Poor	0.25
		Acceptable	0.50
		Good	0.75
		Excellent	1.00

Table 5

Main features of Catamayo – Chira River Basin and its subbasins

Basin	Area (km^2)	Location	WPI
Quiroz	3,108.766	Peru	✓
Chira	4,711.898	Peru	✓
Chipillico	1,170.927	Peru	✓
Alamor	1,190.273	Ecuador – Peru	×
Macará	2,833.290	Ecuador – Peru	×
Catamayo	4,184.027	Ecuador	×
Total	17,199.181	Ecuador – Peru	

Table 6

Final values for all e-WPI parameters

Component	Basin	Pressure		State		Response		
		Value	Level	Value	Level	Value	Level	Result
Resources (water quantity)	Quiróz	-0,33%	0,75	Acceptable	0,5	0,59	0,25	0,54
	Chipillico	0,62%	0,5	Poor	0,25	0,65	0,5	0,50
	Chira	1,47%	0,5	Very Poor	0	0,76	0,75	0,42
Resources (water quality)	Quiróz			Good	0,75			
	Chipillico			Good	0,75			
	Chira			Very Poor	0			
Access (safe water)	Quiróz	29,47%	1	18,35%	0	Poor	0,25	0,42
	Chipillico	22,75%	1	25,77%	0	Poor	0,25	0,42
	Chira	10,95%	0,75	67,97%	0,75	Poor	0,25	0,58
Access (improved sanitation)	Quiróz	14,38%	0,75	27,08%	0	Very Poor	0	0,25
	Chipillico	18,87%	0,75	39,25%	0,25	Very Poor	0	0,33
	Chira	11%	0,75	81,78%	1	Poor	0,25	0,67
Capacity	Quiróz	13,87%	0,75	0,48	0,25	2,39	0,25	0,42
	Chipillico	14,29%	0,75	0,46	0,25	2,90	0,25	0,42
	Chira	9,31%	0,5	0,57	0,5	2,38	0,5	0,50
Use	Quiróz	8,01%	0,5	49,56%	0,75	Poor	0,25	0,50
	Chipillico	8,01%	0,5	67,29%	0,5	Poor	0,25	0,42
	Chira	8,01%	0,5	99,91%	0	Poor	0,25	0,25
Environment	Quiróz	55	0,5	51,8%	0,75	Poor	0,25	0,50
	Chipillico	28	0,75	60,8%	1	Poor	0,25	0,67
	Chira	286	0	70,4%	1	Poor	0,25	0,42
Results	Quiróz		0,675		0,45		0,225	0,45
	Chipillico		0,675		0,425		0,275	0,46
	Chira		0,45		0,475		0,4	0,44